GEARED DRIVE SYSTEM FOR A BLADED PROPULSOR

TECHNICAL FIELD

This invention relates generally to torque transmission systems and more particularly to a geared drive system for powering a bladed propulsor.

BACKGROUND ART

Torque is often transmitted through rotating machines from a source of torque to an output device or component. One example is a bladed propulsion system for powering aircraft. In such systems, a powerplant is the source of torque and rotary motion. A drive system conveys the torque and rotary motion to propulsor blades which may be a propeller or fan of a reciprocating engine or gas turbine engine. Frequently, it is desirable or necessary for the rotational speed of the propulsor blades to be different, generally slower, than that of the power plant.

One way to drive the fan at a rotational speed slower than that of the power plant is to employ a geared drive system which includes a planetary gear train as a member of the drive system. Planetary gear trains are well known and include three gear assemblies—a sun gear assembly including a sun gear, a ring gear assembly including a ring gear, and a planet gear assembly including a planet carrier supporting a plurality of planet gears disposed mechanically intermediate of and in meshing engagement with the ring gear and the sun gear. The sun gear, ring gear and planet carrier share a common longitudinally extending central axis about which at least two of them rotate. The planet gears each have an individual axis of rotation. Typically, the sun gear, ring gear, planet carrier and planet gear axes are all parallel.

Planetary gear trains are highly versatile. In certain planetary gear trains characterized by a single input and a single output, any one of the aforementioned three gear assemblies can be connected to a rotary input. Either of the other two of the three gear assemblies can serve as an output by being connected to a load to be driven while the remaining gear assembly is held stationary relative to the other two.

A planetary gear train arrangement that accomplishes a speed reduction is one whose sun gear assembly is driven by the power plant and whose ring gear assembly is stationary. The planet gears each rotate about their individual axes while simultaneously orbiting about the sun gear. The planet gear orbital motion rotates the carrier about the common central axis. The carrier rotary motion is conveyed to the load, in this case the propulsor blades, by an output shaft or other suitable mechanical structure.

A shortcoming of drive systems that include planetary gear trains arises from the torsional deflection that the drive system will necessarily experience under load due to the elasticity of the materials from which the drive system is made. Some of the torsional deflection occurs in the planet carrier. That is, under an operational load, the carrier structure twists about its central axis so that portions of the carrier which are axially spaced from one another are circumferentially displaced relative to each other. When this occurs, the parallelism of the planet gear axes relative to the sun gear and ring gear axes is disturbed.

Such disturbance of the gear axis parallelism is undesirable. Gear tooth geometry is often predicated on parallelism between the sun gear, ring gear and planet gear axes. When the parallelism is disturbed under operational load, the tooth mesh deviates from the optimum, resulting in maldistribution of loads along the gear teeth, unequal sharing of the loads between the plurality of planet gears, accelerated gear tooth wear, increased likelihood of gear tooth breakage and increased noise.

Carrier torsional deflection can also cause wear in the bearing system that supports the planet gears in the carrier. For example, the planets may be supported in the carrier by cylindrical journals that extend through a bore at the center of each planet gear and are securely attached to the carrier. A thin, essentially cylindrical film of lubricant separates the outer periphery of each journal from the bearing surface at the bore of each planet gear. The axis of each journal and the axis of its associated planet gear must remain substantially parallel so that the lubricant film can maintain separation between the gear bore and the journal along the entire axial length of the bearing surface. When the carrier undergoes torsional deflection, each journal is correspondingly deflected along its length, and in particular, its axis becomes skewed or nonparallel relative to the central axis of the gear train. The ability of the planet gear axes to experience a like displacement, thereby remaining parallel to the journal axes, will be at least partially counteracted by the meshing of the planet gears with the ring gear and sun gear. Consequently, the axes of the journals and the axes of the associated planet gears tend to become nonparallel, compromising the lubricant film's ability to separate the journals from the bearing surfaces at the bore of each gear.

The aforementioned problems might be mitigated by designing the gear teeth to be compatible with a predicted amount of nonparallelism, but this approach is completely effective only at a single operating condition. Attempting to accommodate the shortcomings by strengthening the affected components to tolerate the added wear and stress adds weight and physical size and, therefore, is unacceptable in some applications. Furthermore, the inadequacies of conventional geared drive systems are magnified with increasing power transmission requirements.

In view of these problems and the unacceptability of conventional solutions in certain environments, a high capacity, compact, reliable, light weight geared drive system that isolates the gears from the adverse effects of carrier torsional deflection is sought.

DISCLOSURE OF INVENTION

In accordance with the present invention the shortcomings of prior art geared drive systems using planetary gear trains are significantly reduced by pivotable joints which connect the planet carrier to one end of a torque transfer structure or torque frame. The other end of the torque frame is connected to either a rotating load or to a nonrotating support structure. The joint arrangement between the planet carrier and the torque frame isolates the carrier from torsional deflections.

In an exemplary embodiment, the sun gear assembly of a planetary gear train receives torque and rotary motion from a source thereof such as the power plant of an aircraft gas turbine engine. The ring gear assembly remains stationary and the planet carrier, which is part of a planet gear assembly, is rotatably driven about a central axis by the orbital motion of a plurality of planet gears in a well known manner. A torque transfer structure or torque frame forms at least part of the mechanical path between the planet carrier and the load being driven.

The torque frame is circumferentially discontinuous at a